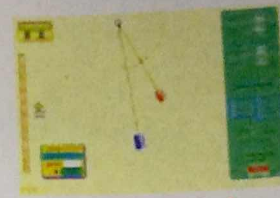
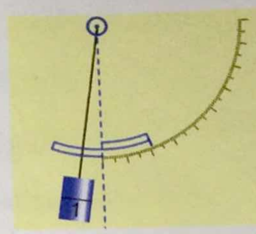
The Pendulum – Introduction to Harmonic Motion PhET Lab

Introduction:



Pendulum Lab

Old grandfather clocks have large pendulums that swing back and forth to keep time. A Foucault pendulum is a huge pendulum that swings in two axes as the earth rotates to also keep time. The time a pendulum takes to swing back and forth (*one cycle*) is referred to as one ***period***. The period of a pendulum is measured in seconds and is given by the formula shown below. The inverse of period is ***frequency***, the number of complete cycles each second. The ***equilibrium*** *position* is the point below the pivot, at a neutral position. The ***amplitude*** of the pendulum's swing is the displacement from the equilibrium. The top of each swing is referred to as ***maximum displacement*** or ***maximum amplitude***.



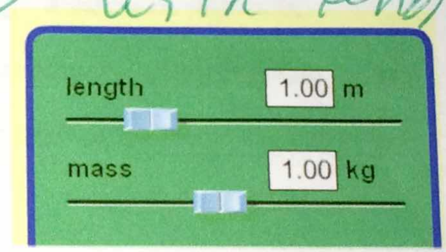
Important Formula: $f = \frac{1}{T}$ **For small amplitudes/angles:** $T = 2\pi\sqrt{\frac{l}{g}}$

Procedure: *Play with the Sims → Motion → Pendulum Lab* Run Now!

1. Spend some time learning about pendulums. The simulated pendulum is frictionless, so it will attain the same amplitude in every swing. That is, it will lose no *energy* to friction (heat).
2. Using a 1.00 kg pendulum, adjust the length of the pendulum and determine the period. (In this lab, you may use the photogate timer to determine the period, but in the next lab, the spring lab you will not have this luxury.)
3. Complete the table below. Each drop is from a -45 degree angle.

Mass (kg)	Length (m)	Period (s)	gravity
1.00 kg	0.50	1.4749	Earth
1.00 kg	1.00	2.086	Earth
1.00 kg	1.50	2.555	Earth
1.00 kg	2.00	2.9503	Earth

← Period increases with length



4. Repeat the investigation but adjust only the mass of the pendulum, leaving all other variables constant.

Mass (kg)	Length (m)	Period (s)	gravity
0.50	2.00	2.9503	Earth
1.00	2.00	2.9503	Earth
1.50	2.00	2.9503	Earth
2.00	2.00	2.9503	Earth

← No change in Period

5. Repeat the experiment, but adjust the gravity (location) leaving all other variables constant.

Mass (kg)	Length (m)	Period (s)	gravity
1.00	2.00	7.1508	Moon hight
1.00	2.00	2.9503	Earth 3
1.00	2.00	1.8155	Jupiter 1
1.00	2.00	2.4521	Planet X 2

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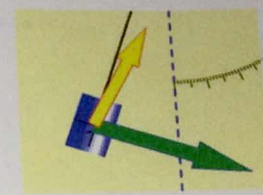
Simulations at http://phet.colorado.edu/ Name: ____Key________________

…elocity and Acceleration Vectors

6. Turn on the velocity and acceleration vectors.
7. Observe the magnitudes and directions of the vectors as the pendulum moves.
8. The green vector represents __**velocity**___ and the yellow vector _**acceleration**___.



Lab Questions and Calculations:

½-point each

1. What force causes the pendulum to speed up on the way down and slow down on the way up? __**Force of Gravity**__
2. As pendulum length increases, the period of harmonic motion ***increases*** / *decreases* / *remains the same.*
3. As pendulum mass increases, the period of harmonic motion *increases* / *decreases* / ***remains the same***.
4. As gravity (Jupiter) on the pendulum increases, the period of harmonic motion *increases* / ***decreases*** / *remains the same.*
5. A pendulum attains maximum velocity ***at the equilibrium position*** / *at maximum amplitude.*
6. A pendulum attains minimum velocity *at the equilibrium position* / ***at maximum amplitude***.
7. A pendulum attains maximum acceleration *at the equilibrium position* / ***at maximum amplitude***.
8. A pendulum attains minimum acceleration ***at the equilibrium position*** / *at maximum amplitude.*
9. A pendulum attains maximum PE (potential energy) *at the equilibrium position* / ***at maximum amplitude***.
10. A pendulum attains minimum KE (kinetic energy) ***at the equilibrium position*** / *at maximum amplitude.*
11. Consider a playground swingset. Is it possible for a kid to swing over the middle bar? __**NO**________
12. Why / Why not?________**He or she would not have enough potential energy.**________________
13. In real devices that use pendulums (clocks, Foucault pendulums in museums) a force must be added to counteract friction. When should that force be applied? *Constantly* / ***at the same period as the pendulum*** / *it doesn't matter.*
14. A pendulum that completes a cycle in 4 seconds has a period of ___**4**_______seconds.
15. That same pendulum has a frequency of_____**0.25**_____cycles per second (Hz)
16. If a pendulum completes 25 cycles in a minute, its period is ___**2.4**_______seconds.
17. …and its frequency is ____**0.42**_____Hz.
18. What is the period (on earth) of a .25 kg pendulum with a length of .45 m? ___**1.35 seconds**
19. What is the period (on earth) of a 7.5 kg pendulum with a length of .45 m? ___**1.35 seconds**___
20. In order to swing with a period of exactly 2.0 s, a grandfather clock's 1.5 kg pendulum must have a length of __**0.99 m.**

Click on *Show Energy* More about PE and KE next unit!

PhET Pendulum Lab Calculations

(14) $f = \frac{1\ cyc}{4\ sec} = 0.25\ \frac{cyc}{sec}$

$T = \frac{1}{f} = \frac{1}{0.25\ \frac{cyc}{sec}} = 4\ sec$

(15) $f = \frac{1\ cyc}{4\ sec} = 0.25\ \frac{cyc}{sec}$

(16) $f = \frac{25\ cyc}{min} \cdot \frac{1\ min}{60\ sec} = 0.42\ \frac{cyc}{sec}$

$T = \frac{1}{f} = \frac{1}{0.42\ \frac{cyc}{sec}} = 2.4\ sec$

(17) $f = \frac{25\ cyc}{min} \cdot \frac{1\ min}{60\ sec} = 0.42\ \frac{cyc}{sec}$

(18) $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{0.45\ m}{9.81\ \frac{m}{s^2}}} = 1.35\ sec$

(19) Same as 18 = 1.35 sec

(20) $T = 2\pi\sqrt{\frac{l}{g}}$, so $T^2 = 4\pi^2 \frac{l}{g}$, 39.24

so $l = \frac{T^2 \cdot g}{4\pi^2} = \frac{(2.05)^2 \cdot 9.81\ \frac{m}{s^2}}{4\pi^2} = 1.99\ m$